ANNEX B
HAZARD ANALYSIS

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1. INTRODUCTION

This hazard analysis (HA) was developed to support the Destruction Plan of chemical-filled items using the Explosive Destruction System (EDS) Phase 2 at Dugway Proving Ground (DPG), Utah. The items contain mustard agent (distilled sulfur mustard [HD] and thickened mustard [HT]), sarin (GB), soman (GD), and O-ethyl S-(2-diisopropylaminoethyl)methylphosphonothioate (VX) or are possibly empty. This HA is an analysis of hazards associated with handling and destroying chemical-filled items and Department of Transportation (DOT) bottles, hereafter referred to as chemical warfare materiel (CWM) items, at DPG and is performed in accordance with the *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product* (PMCD, 2001). In the HA, potential incidents that could occur during the destruction process are discussed qualitatively. To assign relative values to potential risk, risk assessment codes (RACs) are identified for each hazard or hazardous condition. Recommended controls for reduction of risks are included in **Attachment B-1** to this annex.

2. CONCEPT OF OPERATIONS

The concept of operations is in the Destruction Plan. Please refer to **Tables 1-1**, **1-2**, and **1-3** for a list of items to be destroyed.

The scope of this HA covers the site location of the EDS, moving the items from the storage location (Igloo G) to the EDS, and loading the items into the EDS for destruction and treatment. This HA covers hazards specific to EDS operations at DPG, which are

in addition to hazards described in the EDS system HA and reported in the *Explosive Destruction System, Phase 2 Unit 1, Hazard Tracking Log* (PMCD, 2004).

2.1 Assumptions

The following assumptions have been applied to this plan:

- The items consist of both non-stockpile and stockpile items. Descriptions of the items are detailed in **Tables 1-1**, **1-2**, and **1-3**.

- The items are overpacked in propellant charge cans (PCCs) or multiple round containers (MRCs).

- The Destruction Plan includes movement of the items from Igloo G to the EDS; destruction by the EDS; treatment of the chemical fill; and waste delivery to DPG for final disposition.

- The Project Manager for Non-Stockpile Chemical Materiel (PMNSCM) will address the effects of a mishap of handling CWM on the EDS and the environment.

- PMNSCM will address the hazards of operating the EDS.

2.2 Facility Description

The EDS site will be located on level ground near Igloo G and accessible to support services and emergency responders. For additional detail of the facility description, refer to section 2 of the Destruction Plan.

2.3 Facility Location

The EDS will be approximately 122 feet from Igloo G where the items are currently located. Both facilities are within the confines of a restricted area at DPG.

2.4 CWM Characterization

The items that will be destroyed using the EDS are described in **Tables 1-1**, **1-2**, and **1-3** of the Destruction Plan.

3. HAZARD ANALYSIS

To aid in evaluating identified hazards, potential incident and accident scenarios have been defined and RACs have been assigned in accordance with the *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product* (PMCD, 2001). The RACs are based on combinations of hazard severity categories and hazard probability (or frequency of occurrence) categories. The definitions of the hazard severities and hazard probabilities are listed in **Tables B-1** and **B-2**, respectively, and the RAC matrix is provided in **Table B-3**.

A summary of the hazards identified, along with the RACs assigned, is provided in **Attachment B-1**. Hazards assigned RAC 1 require corrective action prior to acceptance of the plan. Hazards assigned RAC 2 also require corrective action, but are of lower priority than RAC 1 hazards. If resolutions do not lower the RAC to 3 or 4, the RAC 1 and RAC 2 hazards must be formally accepted by the designated authorities in accordance with the *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product*.

Table B-1. Hazard Severity Categories

Description	Category	Mishap Definition
Catastrophic	I	May cause death, system loss, or severe environmental damage.
Critical	II	May cause severe injury, severe occupational illness, or major system or environmental damage.
Marginal	III	May cause minor injury, minor occupational illness, or minor system or environmental damage.
Negligible	IV	May cause less than minor injury, occupational illness, or less than minor system or environmental damage.

Source: Program Manager for Chemical Demilitarization, *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product*, August 2001

Table B-2. Hazard Probability Categories

Frequency of Occurrence	Level	Description
Frequent	A	Will be continuously experienced.
Probable	B	Will occur frequently in the life of the system.
Occasional	C	Will occur several times in the life of the system.
Remote	D	Unlikely, but can reasonably be expected to occur in the life of the system.
Improbable	E	Unlikely, but possible to occur in the life of the system.

Source: Program Manager for Chemical Demilitarization, *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product*, August 2001

Table B-3. Risk Assessment Codes

Frequency of Occurrence	Consequence Category			
	I Catastrophic	II Critical	III Marginal	IV Negligible
A - Frequent	1	1	1	3
B - Probable	1	1	2	3
C - Occasional	1	2	3	4
D - Remote	2	2	3	4
E - Improbable	3	3	3	4

Hazard Risk Index	Risk Assessment Code	Action Required
IA, IB, IC, IIA, IIB, IIIA	1	Unacceptable - immediate corrective action required. Asst. Sec. Army Decision.
ID, IIC, IID, IIIB	2	Undesirable - reduced priority, corrective action required. Project Manager for Non-Stockpile Chemical Materiel decision.
IE, IIE, IIIC, IIID, IIIE, IVA, IVB	3	Acceptable - low priority for corrective action (may not warrant action). System Safety Program Manager decision.
IVC, IVD, IVE	4	Acceptable - no corrective action required.

Source: Program Manager for Chemical Demilitarization, *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product*, August 2001

4. TRANSPORTATION

Movement of the items from Igloo G to the EDS will be by truck. The transportation route is approximately 122 feet long. There will be a maximum of 69 trips to move all the munitions, one item at a time for a total of 1.6 miles. The basic truck accident rate is 6.87×10^{-8} accidents per mile. Multiplying the accident rate times the distance traveled and the number of trips (69 trips $\times$ 1.6 miles $\times$ 6.87×10^{-8}) yields an accident probability of 7.58×10^{-6} accidents per mile for movement of all of the munitions from Igloo G to the EDS.

According to the *System Safety Management Plan for the Non-Stockpile Chemical Materiel Product* (PMCD, 2001), such an event is "improbable" (probability category E). Since a transportation accident could have catastrophic effects (severity category I), the resulting RAC is 3 (IE) for transportation hazard probability.

5. MAXIMUM CREDIBLE EVENT (MCE)

Department of the Army Pamphlet (DA Pam) 385-61 defines an MCE as a worst-case accident scenario that results in the release of agent and that has a reasonable probability of occurrence. The MCE for this operation is the evaporative release of 2,067 milliliters (mL) of GB from a DOT bottle.

Many of the hazards analyzed here relate to releases of CWM into the environment. The D2PC computer code[1] (Whitacre, et al., January 1987) was used to evaluate the consequences of evaporative agent release scenarios. D2PC is an atmospheric dispersion model that computes the rate of evaporation and dispersion of chemical warfare agents. **Attachment B-2** shows the results computed by D2PC. For daytime

[1] D2PC is a U.S. Army-approved computer program that provides estimates of downwind chemical agent hazard distances.

releases, a reasonable worst-case wind speed of 1 meter per second and an atmospheric stability category of D were used. The 1 percent lethality distance for an evaporative release of one DOT bottle containing 2,067 mL of GB is 277 meters (892 feet).

6. EXPLOSIVE HAZARD DISTANCE

Explosive hazards include the fragmentation hazard and the blast hazard and are determined from quantity-distance (Q-D) tables in DoD Std 6055.9. The combined net explosive weight (NEW) for the explosives contained in the item being treated and the donor explosives that will be used to operate the EDS is less than 5 pounds. In accordance with DoD 6055.9, Table C9.T5, the intraline distance is 66 feet for 5 pounds of explosives.

7. MITIGATION OF HAZARDS

Table B-4 contains a summary of the handling, movement, and EDS operational events; possible incidents; and hazards associated with the incidents. In addition, the following paragraphs provide more specific information on how to mitigate hazards associated with handling, moving, destroying, and neutralizing CWM.

The location of the EDS site allows separation from public areas should an accident occur. The location is served by roads that allow response personnel access to the site.

An Emergency Medical Technician and ambulance will be on duty during chemical operations.

Two-way radio and cellular telephone communications are available in the event of an accident.

Table B-4. Summary of Identified Hazards and RACs

Item	Hazard	Uncontrolled RAC	Controlled RAC
Hazards During Handling			
001	Explosive rupture of a munition in the EE	2	2
002	Dropping a munition or cylinder without an explosion in the EE causing a leak	2	3
003	Improper lifting	2	3
004	Crushing a body part due to dropping an item without an explosion or release in the EE	2	3
005	Tripping/falling injuries resulting from poor housekeeping	2	3
006	Improper handling of decontaminants	2	3
007	Heat stress/strain injuries	2	3
008	Cold stress injuries	2	3
Hazards During EDS Operations			
009	Decontamination solution exposure	2	3
010	Drum handling mishap	2	3
Transportation			
011	Vehicle accident due to road conditions	3	3

Notes:

The Program Manager for Chemical Demilitarization, *Phase 1 Unit 2, Hazard Tracking Log*, Final, September 2002, has captured system-specific hazards that are not repeated in this HA.

EDS = Explosive Destruction System
EE = Environmental Enclosure
RAC = risk assessment code

Edgewood Chemical Biological Center (ECBC) personnel will perform chemical agent monitoring of the EDS Environmental Enclosure (EE). Inspection of facilities and monitoring of the work environment will reduce the probability of leaks occurring and will preclude workers from entering an immediately dangerous to life and health contaminated area unknowingly.

When handling CWM, workers shall minimize the handling to reduce the likelihood of dropping. Workers should wear work gloves, safety shoes, and use proper lifting techniques and lifting mechanisms. Explosive operators shall be trained in proper handling techniques and in the use of personal protective equipment (PPE).

Explosive operators will conduct CWM handling. Explosive operators are trained in handling armed and burstered chemical munitions. The use of PPE will protect explosive operators from hazards resulting from release of agent. Radio communication is available in the event of an accident. The EDS will be positioned, within safety guidelines, close to the CWM storage location to minimize the distance explosive operators must move the munition.

Implementation of these mitigators can reduce both the severity and probability of hazards that can occur.

8. SUMMARY

An HA that encompasses the risk potential of handling, moving, and destroying CWM has been performed for the Destruction Plan. The proposed site for the EDS operations is acceptable. Hazards were identified from the concept of operations and from historical information, and RACs were assigned based on consequence severity and frequency of occurrence. There were 11 hazards identified. Ten were assigned controlled RAC 3 and are acceptable with review. One was assigned a RAC 2. This

hazard involves the remote chance of personnel dropping the munition during handling, resulting in a detonation. The PMNSCM has accepted this hazard.

ATTACHMENT B-1
HAZARD CONTROL LOG WORKSHEETS

Table B-1-1. Assessment Plan Hazards

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
Hazards During Handling								
001	Explosive rupture of munition in the EE	Munition may be dropped while being moved in the EE or when removed from the overpack	Death or serious injury	2 (ID)	Only trained personnel will handle the munition; all others will remain outside the hazardous fragmentation distance. Non-essential personnel will remain outside the 1 percent lethality distance. (Essential support personnel [e.g., first responders, select EDS operators, monitoring operators] may be outside the hazardous fragmentation distance but inside the 1 percent lethality distance.)	Trained personnel will do all of the handling. All other personnel will be evacuated from the area.	2 (1D)	Item 001 looks at a dropped munition and overpack unpacking hazard.

Table B-1-1. Assessment Plan Hazards (Continued)

002	Uncontrolled release of hazardous chemicals in the EE	Dropping an item while unpacking without an explosion in the EE	Exposure to chemical agent	2 (ID)	Train workers in proper use of mechanical lifting equipment and provide PPE.	Workers will be wearing Level C PPE when handling the item.	3 (IE)
003	Heavy object	Improper lifting	Muscle strain to operator	2 (IID)	Train workers in proper lifting techniques; use mechanical lifting devices when possible.		3 (IIE)
004	Heavy object	Dropping an item onto a body part without an explosion or release in the EE	Crushing injury	2 (IID)	Do not lift more weight than is recommended by MIL-STD-1472; Use proper lifting devices that are in good condition; Do not position body parts under heavy items.		3 (IIE)
005	Tripping/falling hazard	Poor housekeeping	Strain, sprain, or broken bone	2 (IID)	Store overpacks properly. Remove tripping hazards from work areas.		3 (IIE)

Table B-1-1. Assessment Plan Hazards (Continued)

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
006	Chemical spill/release	Improper handling of decontamination chemicals	Exposure to chemicals	2 (IID)	Train personnel in proper decontamination techniques. Ensure proper PPE selection.		3 (IIID)	
007	Excessive temperature, work load, humidity, and/or PPE combination	Working in a hot environment and/or wearing PPE	Heat stress/strain injuries	2 (IID)	Provide conditioned air for hot work environment. Train workers in injury prevention and recognition. Implement a comprehensive heat stress plan.		3 (IIID)	
008	Cold environment	Insufficient cold protection	Cold stress injuries	2 (IID)	Provide heated spaces where workers can warm up. Train workers in injury prevention and recognition.		3 (IIID)	
Hazards During EDS Operations								
009	Chemical spill/release	Improper handling of decontamination chemicals during EDS neutralization	Exposure to chemicals	2 (IID)	Train personnel in proper mixing techniques. Ensure proper PPE selection.		3 (IIID)	

Table B-1-1. Assessment Plan Hazards (Continued)

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
010	Heavy object	Improper lifting/movement of waste drums	Muscle strain/sprain to operator	2 (IID)	Train workers in proper lifting techniques; use mechanical lifting devices when possible.		3 (IIE)	
Hazards During Transportation (if item will be moved by vehicle)								
011	Road conditions (that is, traffic, drivers, weather)	Vehicle accident	Body trauma and/or vehicle damage	3 (IE)	Follow chemical weapon escort procedures when transporting munition from storage bunker to EDS.		3 (IIE)	

Notes:

The Program Manager for Chemical Demilitarization, *Phase 1 Unit 2, Hazard Tracking Log*, Final, September 2002, has captured system-specific hazards that are not repeated in this HA.

EDS = Explosive Destruction System
EE = Environmental Enclosure
MIL-STD = Military Standard
PPE = personal protective equipment
RAC = risk assessment code

ATTACHMENT B-2
D2PC CALCULATION

ATTACHMENT B-2
D2PC CALCULATION

The following is a printout showing the inputs to the D2PC model used to estimate hazard distances for the EDS at DPG Destruction Plan.

```
          --------------------------------
          | DOWNWIND HAZARD PROGRAM D2PC |
          -------------------------------- 2
  TYPE ? FOR DEFINITIONS

1. YOUR NOVICE LEVEL: 3,2,1 OR 0 NOV
INPUT:1

2. LOCATION                LOC
    AAD,DPG,EWA,JHI,LBG,NAP,PBA,PAD,RMA,UAD,EUR,NDF
INPUT:DPG

3. SEASON                  SEA
    WIN,SPR,SUM,FAL
INPUT:SUM

5. MUNITION TYPE           MUN
    105,155,8IN,500,750,M55,525,139,M23,4.2,TON,TMU,NON
INPUT:NON

6. AGENT TYPE              AGN
    GA,GB,GD,GF,VX,BZ,HY,UD,HD,H1,H3,HT,LL,AC,
    CG,CK,DM,EG,QL,DF,DC,TC,PR,IP,ZS,KB,NA
INPUT:GB

8. RELEASE TYPE            REL
    INS,EVP,SEM,VAR,STK,STJ,FLS,FIR,IGL,EVS
INPUT:EVP
```

9. STABILITY TYPE STB
A,B,C,D,E,F,U,S,W
INPUT:D

10. WINDSPEED (M/SEC) WND
INPUT:1
BRT=25. DI= .5 6.0 10.0

7. SPILL OR AIRBORNE SOURCE (MG) QQQ
INPUT:ML2067
ML TO MG .225E+07

SURFACE
12. TEMPERATURE (DEG C) TMP
INPUT:30

17. SURFACE CODE SUR
GRA,CON,NDF
INPUT:CON

18. TIME OF EVAPORATION (MIN) TEV
INPUT:60
CON EVR=3.455E+03(MG/MIN-SQ M) AREA=2.723E+00(SQ M) VPR=3.890E+00
Q=2.250E+06(MG) Q'=5.644E+05(MG) TEV=6.000E+01(MIN)
ALL OTHER INPUT
ALL

1 MUN:NON AGN:GB REL:EVP WND= 1.0(M/S) TMP=30.0(C) DPG-SUM STB:D

Q(MG) TS(MIN) HTS(M) HML(M) SXS(M) SYS(M) SZS(M)
5.644E+05 6.00E+01 .00E+00 2.00E+02 5.50E-01 5.50E-01 1.00E-01 D

W/2-MINUTE CORRECTION

214. (M) IS DISTANCE TO 1% LETHALITY

288. (M) IS DISTANCE TO NO DEATHS

W/O 2-MINUTE CORRECTION

1855. (M) IS DISTANCE TO NO EFFECTS

ALL OTHER INPUT